ORIGINAL RESEARCH ARTICLE

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Dietary exposure to persistent organic pollutants and metals among Inuit and Chukchi in Russian Arctic Chukotka

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Objectives. The general aim was to assess dietary exposure to selected persistent organic pollutants (POPs) and metals among Eskimo (Inuit) and Chukchi of the Chukotka Peninsula of the Russian Arctic, and to establish recommendations for exposure risk reduction.

Study design. A cross-sectional evaluation of nutritional patterns of coastal and inland indigenous peoples of the Chukotka Autonomous Okrug (in 2001–2003); assessment of the levels of persistent toxic substances (PTSs) in traditional foods and their comparison to Russian food safety limits; the identification of local sources of food contamination; and the recommendation and implementation of risk management measures.

Methods. Community-based dietary survey of self reported food frequencies (453 persons), chemical analyses (POPs and metals) of local foods and indoor matters (397 samples), substantiation of recommendations for daily (weekly, monthly) intakes of traditional food.

Results. POPs in traditional food items are generally below the Russian food safety limits except marine mammal fat, while Hg and Cd are high mainly in mammal viscera. Lead is relatively low in tissues of all animals studied. For the Chukotka coastal communities, seals constitute the principal source of the whole suite of PTSs considered. Consumption restrictions are recommended for marine and freshwater fish, some wild meats (waterfowl and seal), fats (whale and seal), liver (most animals) and kidney (reindeer, walrus and seal). Evidence is presented that contamination of foodstuffs may be significantly increased during storing/processing/cooking of food due to indoor and outdoor environmental conditions.

Conclusions. Based on the analytical findings and the local PTSs sources identified, guidelines on food safety are suggested, as well as measures to reduce food contamination and domestic and local sources. Important and urgent remedial actions are recommended to minimize PTSs environmental and domestic contamination. Waste clean-up activities started in coastal Chukotka in 2007.

Keywords: *Chukotka*; *Russian Arctic*; *indigenous people*; *traditional food*; *PTSs*; *POPs*; *metals*; *food safety limits*; *exposure risk*

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The Chukotka Autonomous Okrug (ChAO) is located on the north-eastern end of the Eurasia continent, and occurs as a wedge between the Pacific Ocean and the Arctic Ocean. It is surrounded by the Eastern Siberian Sea, the Chukotka Sea and the Bering Sea. The Bering Strait separates Chukotka from the USA Alaska. Half of the ChAO is above the Polar Circle.

The population size of ChAO currently is about 50,500 people, with a population density of 0.07 person/km^2. City dwellers (37,000) comprise about 67% of the total population. The indigenous people are multinational: 14,600 persons represent several small nationalities of the Russian North, namely Chukchi (75%), Eskimo (9%), Eveni (8%), and Chuvantsi (6%). Coastal ChAO is the only Russian region where about 1,300 Eskimo (original Inuit) live and where marine mammal hunting exists.

Chukotka inland natives are primarily engaged in reindeer breeding, compared to marine mammal hunting by coastal natives. Along with employment in commercial cooperatives, fishing and hunting are common personal and family activities of the aboriginal population. Living conditions of people in the remote settlements (mostly coastal) are still meager and demand improvement.

Most dwellings in Chukotka are built on piles because of the deep permafrost which also eliminates the availability of artesian water. The majority of settlements have

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centralized drinking water systems, delivered by pipes from the nearest lake or river; township sewage treatment and water purifying systems are absent as a rule. Some settlements, where the average annual temperatures are well below 0, have a water-delivery system that serves as the centralized heating and water supply; this water is also used for drinking and the cooking of food. In some remote villages wooden houses (so-called "chukotsky houses") without such centralized water delivery system are common, and dwellers use firewood (and/or coal) for heating. Inland reindeer-herders spend several months a year in tundra where a brigade (or family) live in "jarangas" (mobile tents made of reindeer skin). Hand-made "baydaras" (kayaks) are in use in coastal areas and dog teams are the main transport for hunters and fishermen; the use of snowmobiles and motorboats are rare. Even though westernization of lifestyle and adaptation to Christianity of the indigenous people has occurred, many of their traditions are still practiced. Classical Chukotka Shamanism is non-existent, though many people continue to worship pagan deities and ghosts (of tundra, ocean, mountains, etc.). Smoking and alcohol consumption is widespread among the native peoples.

It is well known that persistent toxic substances (PTSs) in the Arctic are able to bioaccumulate and biomagnify in food chains, which cause enhanced levels of exposure of indigenous people to persistent organic pollutants (POPs) and metals and increases the risk of adverse health effects[1]. An association between traditional food consumption and high body burdens of PTSs among indigenous people of the Arctic is well established (1–4). Examples of total diet studies that include contaminant analysis of foods have been conducted in Greenland and in Canada under Canadian Northern Contaminants Program (NCP) (4–5). An overview of the dietary surveys undertaken in different native Russian Arctic communities is summarized in a supplement of the journal Circumpolar Health (6), although none of them was done in the context of PTSs exposure. Some scattered information on contamination by PTSs of wildlife foods in the Russian Arctic during the 1990s by the Arctic and Antarctic Research Institute (St-Petersburg) has been presented in AMAP reports (1,2). Though the results obtained in some Russian polar regions have confirmed the main patterns of PTSs contamination of food chains observed in other circumpolar countries, the survey completed in Chukotka is quite unique. The primary reason for this is the investigation of local exposure sources and the possibility, of comparing exposures for two distinct populations-coastal community who consume marine mammals (whale, walrus, seal) as a food staple, and inland community who mainly consume reindeer meat and fish.

At the onset of the new millennium, a lot of gaps in understanding and managing PTSs exposures were apparent. This became the aim of present study: identifying local sources and pathways of contamination; the apparent contradiction between sizeable levels of POPs in the blood of indigenous people and relatively low levels of these contaminants in wild-life tissues; a consideration of safe intakes and exposure reduction measures; and the promotion of improved food security policies in the Russian Arctic, including practical advice for native peoples.

Material and methods

Levels and distribution patterns of PTSs in selected food samples collected during 2001–2003, as well as information about additional sources of food contamination, were reported in the AMAP Russian Arctic PTSs report (7). Additional details, calculations and interpretations are provided in the present paper. Community-based dietary and lifestyle surveys and an environmental exposure assessment that focused on local foods and their preparation, as well as on other domestic exposure sources, were conducted in Chukotka in 2001–2003. The interviews were conducted by specialists from the Northwest Public Health Research Centre (NWPHRC) in St-Petersburg and by local professionals trained onsite (physicians, teachers, administrative workers, etc). The Russian language was used for all survey tools.

Two regions of Chukotka were selected for investigation (Fig. 1); specifically, the inland Kanchalan settlement area inhabited by inland Chukchi (reindeer herders), and the coastal Uelen settlement populated by coastal Chukchi and Eskimo.

The dietary survey was based on self-reported weekly (monthly) food frequencies ($n = 453$; see Table I) obtained as part of a larger questionnaire completed by the participants of the AMAP-coordinated study (7); they also donated blood samples.

The study project protocol was approved by the Pasteur Institute Ethics Review Board (St-Petersburg, Russia) on July 12, 2001 (File#11). The food frequency questionnaire was designed to include most of the food items consumed locally and registered the frequency, the amount eaten and the season. Each participant was asked about portion size (in grams) and the frequency of food intake: daily; 2–3 meals/week; weekly; 2–3 meals/month; monthly or rarely. From the reported intake frequencies and portion sizes, the average consumptions per day (week, month, year) were calculated for each main foodstuff item.

1. POPs constitute a sub-group of 21 PTSs that are included in the Stockholm convention of Persistent Organic Pollutants. Available from: http://chm.pops.int.

Fig. 1. Map of the study areas.

Samples of fish (marine, migratory, freshwater), birds (terrestrial, waterfowl), meat and viscera of mammals – inland (reindeer, Siberian moose, hare) and marine species (whale, walrus, seal) were collected. Bearing in mind that hunting and fishing grounds can be located at some distance from the actual settlements, and that migration of reindeer herds depends upon the season and weather conditions, field sampling was based on prior consultations with the local indigenous peoples involved in such traditional activities. The sampling of onsite environmental media was designed to identify domestic sources. For biota species at higher trophic levels, specific organs and tissues known to be important with respect to PTSs accumulation, were sampled. Tissue and organ samples from animals of the same sex and similar age groups were pooled. An exception to this approach was made in the case of marine mammals that feed at the top of the marine food chain and accumulate particularly high levels of lipophilic contaminants. For these animals, samples were treated and analysed individually and not pooled. Standardized and prescribed sampling, pre-treatment, storage and transportation procedures were used to ensure that contamination was avoided and paying due diligence to quality control measures. Environmental sampling was carried out in six areas within the project region. The latter were located around the settlements with the highest indigenous populations. All samples were frozen immediately after delivery to the field camp, and stored frozen until shipped to the laboratory. Details (type and number) of the plant and animal tissues sampled are summarized in Chapters 5 and 6 of the 2004 AMAP report (7). Washouts of indoor areas (walls) were limited to dry non-porous surface squares (400 cm^2 [20×20 cm]) using sterile medical cotton wool tampons (medical, sterile, bleached without chlorine) soaked with hexane (grade 1, pure super, UV absorption 0.5 optical units/cm for 200 nm). Each surface was wiped twice and the 2 tampons were wrapped into aluminum foil and put into a plastic container with screw top (for biological samples, EN 829). Surfaces covered

Table I. Number of indigenous people interviewed from Uelen and Kanchalan

	Uelen	Kanchalan
Chukchi	224	191
Eskimo	24	–
other natives	3	11
Total	251	202

by plaster and/or paint were scraped using a surgical scalpel; the area of scraped surface was about 100 cm^2 (10×10 cm), to a depth of about 1 mm. The surface material was also wrapped in aluminum foil and put into a plastic container with screw top for transport.

Fresh food samples (n = 397) were analysed for the sum of PCBs (Σ PCBs), HCB, sum of HCH (Σ HCHs), sum of DDTs (Σ DDTs, including DDE), mercury, lead and cadmium as well as 15 samples of indoor washings and scrapings, 6 samples of home insecticides and a single specimen of stored, preserved and ready-to-eat food, (including home-made alcoholic beverages) by the Regional Center "Monitoring of the Arctic" (St-Petersburg, Russia) or by the "Typhoon Laboratory" (Obninsk, Russia). Both laboratories had international accreditation for PTSs analyses. Chlordanes, toxaphenes and mirex were also analysed, but since their levels were low (as well as in blood samples) they are not reported. The analytical methods used for PTSs determinations in individual and pooled environmental and biotic samples were based on internationally recognized methodologies, which have been described in detail in the 2004 AMAP report (7). The limits of detection of the POPs in units of ng/g wet weight were: Σ PCBs, 1.0; HCB, 0.05; Σ HCH, 0.20; and Σ DDTs, 0.05. For the three metals they were 0.001 μg/g ww.

Recommended daily intakes for foodstuffs were calculated for a 60 kg person, based on the observed average concentrations of PTSs (both POPs and/or metals) and comparing them with the values of the maximum permissible daily intakes for POPs established in Russia (for Σ HCH, Σ DDTs, and HCB – see Table II) and existing tolerable daily intakes (TDIs), or acceptable daily intakes (ADIs), for Σ PCBs and the metals used by the Contaminants Toxicology Section, Food Directorate and Contaminated Sites Program, of Health Canada (8–10) in units of μg/kg body wt/day: Σ PCBs (1.0), lead (3.57), mercury (0.71) and cadmium (1.0). On average, about two-thirds of the total mercury is methylmercury (10).

Statistical treatment of the data was carried out using the SPSS 13.0 software package and Microsoft Office.

Results

Nutritional patterns for inland and coastal Chukotka

Average annual consumption of local foods by Uelen and Kanchalan indigenous residents are presented in Figs. 2–6.

The annual quantities (in units of ww kg/person/year) of the main food sources of coastal Chukchi and Eskimo (Uelen) were marine mammals (~100 kg) and fish (~70 kg) (mainly polar cod, smelt and salmon), compared to reindeer meat (~70 kg) and fish (~90 kg) (mainly whitefish and grayling) by the inland Chukchi (Kanchalan). The coastal group consumed more birds and wild plants, while the consumption of berries was higher among the inland Chukchi. The consumption of the different local foods varied with the season. Store(market)-bought foods constituted a relatively smaller proportion of the total than the local traditional foods. The main market food consumables for both inland and coastal Chukotka natives in kg/person/year were: macaroni (~14 kg), grains (~10 kg) and sugar (~11 kg).

Contaminants in local food items

Russian food safety limits applicable for Arctic traditional food items are shown in Table II (11–13). As shown, maximum permissible concentrations (MPCs) have been established for all the PTSs considered and the foods which, in context of the current study, constitute "traditional foods" (or the equivalent "local foods" designation).

POPs in local food items

In Chukotka the observed concentrations of POPs in venison and fish (marine, migratory [anadromous], freshwater) were low (e.g. Fig. 7). The levels in birds were 2–4 times higher than in reindeer and fish, but 10 times lower than the MPCs, and decreased in the order: molluscivorous > omnivorous > piscivorous > meadow feeding > ptarmigan. The corresponding levels in marine mammal meat, liver and kidney were also low, but fat tissues clearly accumulated organochlorines (e.g. Figs. 7 and 8). Nevertheless, average Σ PCBs levels in fats of walrus, seal and whale were 20 times lower than the MPCs, and Σ DDTs and Σ HCHs fat levels only slightly exceeded their MPCs.

Metals in local food items

Levels of mercury in venison muscle tissue were very low (Figs. 9 and 10). This also applies to lead (data not shown). In some offal samples enhanced contents occurred, especially cadmium, in reindeer meat, liver and kidneys (up 2 times the MPC), and of mercury in reindeer kidney (around 1.5 times the MPC). Lead levels in reindeer liver and kidneys were low. In both regions, lead and cadmium concentrations in all species of birds did not exceed the MPC values except when lead shot was found in the bird tissue. Waterfowl mercury content for muscle tissue was 2–3 times higher than the MPC. In both regions, levels of metals in all species of fish (marine, migratory, freshwater) did not exceed the MPCs, including burbot liver.

In all species of Chukotka marine mammals, levels of lead in all tissues were significantly lower than the MPC. Cadmium concentrations in marine mammal meat were also low. Livers of whales, walruses and seals were highly contaminated with cadmium, more specifically 5–15

Table II. Russian maximum permissible concentrations (MPCs) and maximum permissible daily intake (MPDIs) of PTSs in food products (11–13)

PTS	Food product	Maximum permissible Concentration (mg/kg ww)	Daily intake (mg/kg body weight/day[a])
HCH	Meat of birds and terrestrial mammals (fresh, chilled and frozen), by-products (liver, kidneys, sausages), canned meat and birds – as in feedstock (recount to fat), eggs	0.1	0.01 – adults; 0.005 – children
	Fat of mammals	0.2	
	Vegetables, mushrooms	0.5	
	Potatoes	0.1	
	Berries	0.05	
	Freshwater fish (fresh, chilled, frozen)	0.03	
	Marine fish (fresh, chilled, frozen)	0.2	
	Meat of marine mammals	0.01	
	Fish salted, smoked, dried	0.2	
	Fish liver, fish liver products, canned fish liver	1.0	
	Fish spawn, fish balyk	0.2	
	Fish oil	0.1	
	Canned fish, canned meat of marine mammals – as in feedstock		
DDT	Meat of birds and terrestrial mammals (fresh, chilled and frozen), by-products (liver, kidneys, sausages), canned meat and birds – as in feedstock (recount to fat), eggs, vegetables, mushrooms, berries	0.1	0.005 – adults; 0.0025 – children
	Fat of mammals	1.0	
	Freshwater fish (fresh, chilled, frozen)	0.3	
	Marine fish (fresh, chilled, frozen), meat of marine mammals, fish oil	0.2	
	Fish salted, smoked, dried	0.4	
	Fish liver, fish liver products, canned fish liver	3.0	
	Fish spawn, fish balyk	2.0	
	Canned fish, canned meat of marine mammals – as in feedstock		
PCB	Fish, meat of marine mammals	2.0	Not established
	Fish liver	5.0	
	Fat of marine mammals	3.0	
HCB	Cereals	0.01	0.0006
Heptachlor	All products	Not allowed	0.0005
Aldrin	All products	Not allowed	0.0001
Lead	Meat, fowl	0.5	Not established
	Liver	0.6	
	Kidneys	1.0	
	Fish, fish liver, meat of marine mammals	1.0	
Cadmium	Meat, fowl	0.05	Not established
	Liver	0.3	
	Kidneys	1.0	
	Fish, meat of marine mammals	0.2–0.6	
	Fish liver	0.7	
Mercury	Meat, fowl	0.03	Not established
	Liver	0.1	
	Kidneys	0.2	
	Fish, fish liver, meat of marine mammals	0.3–0.6	

[a]The Russian MPDIs listed correspond to current or earlier WHO acceptable daily intakes (ADIs) or provisional tolerable daily intakes (PTDIs) (14); that for HCH corresponds to any combination of $\acute{\alpha}$, β and γ HCH; and DDT refers to any combination of DDT, DDD and DDE.

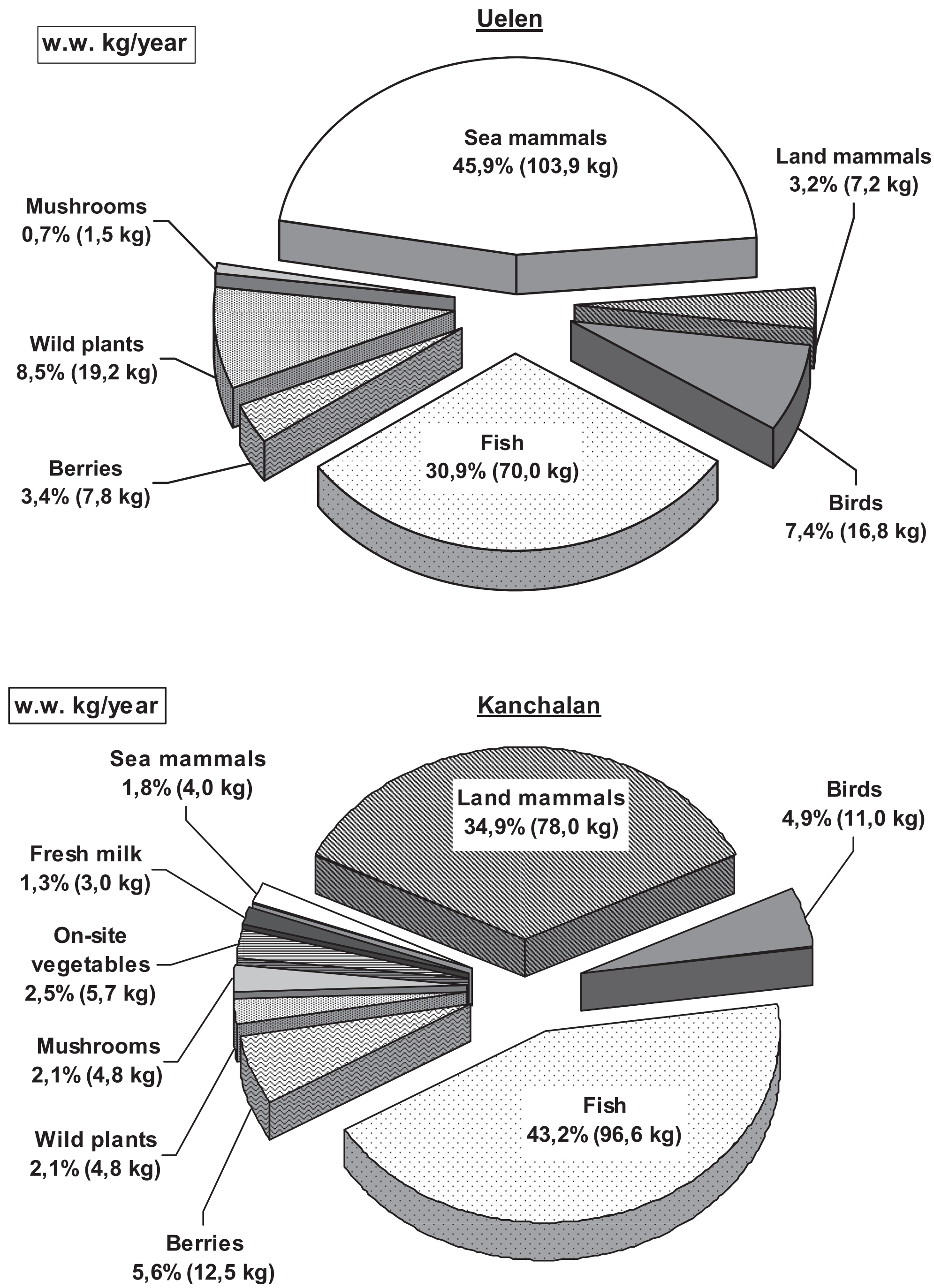

Fig. 2. Average annual consumption of local (traditional) foods by coastal Chukchi and Eskimo (Uelen) and inland Chukchi (Kanchalan); Chukotka, Russia (2001–2002).

times higher than MPC. All species of seals were extensively more contaminated with mercury, than terrestrial mammals, birds and fish. In seal meat it exceeded the MPC by 3–10 times, and by factors of 10 and 20–100 for kidney and liver, respectively. The highest mercury levels were observed for Bearded Seal, particularly in the liver. Meat of walruses and Grey Whales was less contaminated with mercury (<the MPC), while kidneys and liver had mercury levels 2–4 times higher than the MPC. Mercury levels in whale kidney were lower than in liver (near the MPC).

Total intake of each PTS was calculated for a 60 kg person using the self-reported consumption rates reported in Figs. 2–6 and the observed PTS concentrations in the food items. The calculated daily intakes were compared to the MPDIs in Table II. When for a food

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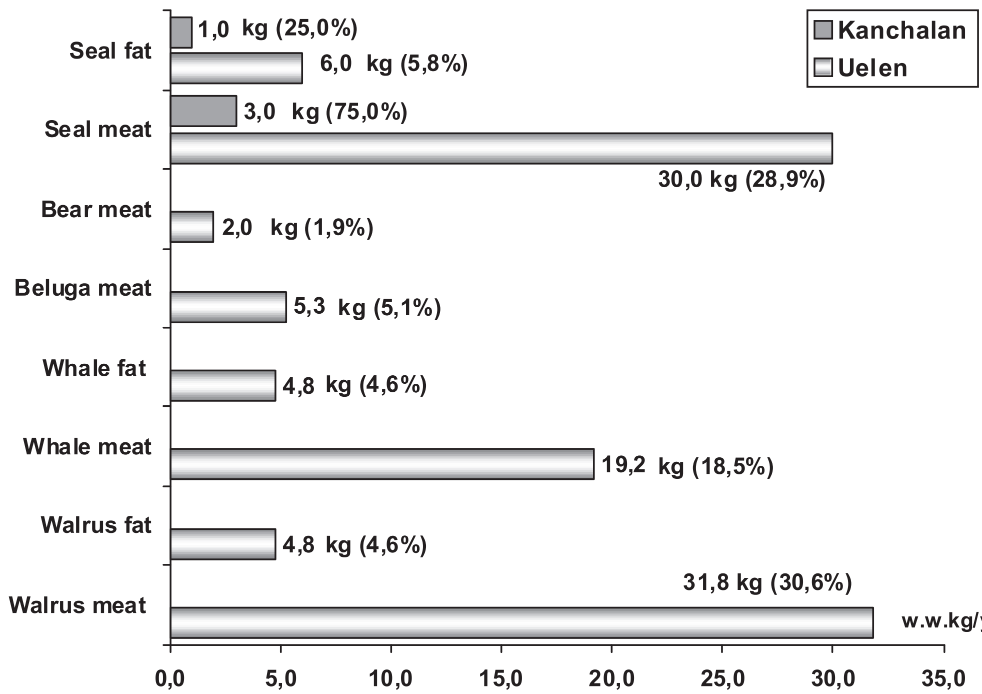


Fig. 3. Average annual consumption (wet weight) of sea mammals by coastal Chukchi and Eskimo (Uelen) and inland Chukchi (Kanchalan). Chukotka, Russia (2001–2002).

item the MPDI was exceeded, a daily consumption rate is suggested that complies with it (see Table III).

From the point of view of PTSs food safety, a perusal of Table III suggests that there should be no anxiety about the eating of reindeer (except liver and kidneys), Siberian Moose, hare, mushrooms, berries, wild plants, and seaweeds. By contrast, consumption restrictions are recommended for fish and fish liver; liver and kidneys of reindeer; meat of waterfowl; meat, liver and kidneys of seal; liver and kidneys of walrus; whale liver; and fat (including mantak) of whale, walrus and seal.

The preliminary findings reported in Table IV suggest that insecticides can constitute a significant source of the POPs investigated, as do homemade alcohol and ground fermented walrus meat. Contaminated containers used in preparing the latter consumables are suspected, although soil as a source for the fermented walrus meat cannot be ruled out (see footnote to Table IV). As reported in the 2004 AMAP report (7), dwelling wall washouts and scraps also contained DDTs and PCBs.

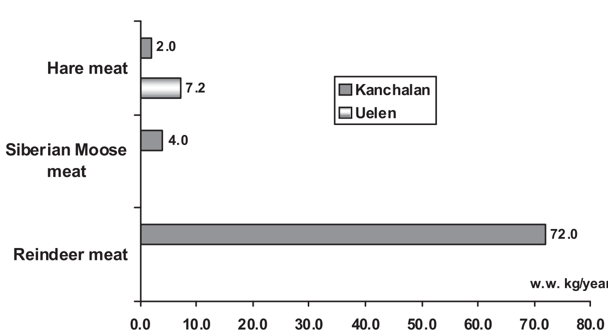


Fig. 4. Average annual consumption (wet weight) of terrestrial animals by coastal Chukchi and Eskimo (Uelen) and inland Chukchi (Kanchalan); Chukotka, Russia (2001–2002).

Discussion

Our results confirm that fatty tissues of sea mammals are the most serious dietary sources of PCBs, HCB, DDTs, HCH and other organochlorine pesticides. Similarly, the offal of these animals (kidney and liver) also appears to be a significant source of mercury and cadmium. The contamination of other traditional foods was generally below the Russian MPCs.

One of the key findings is that the contamination of traditional foods through the long-range and regional transport of pollutants into the Russian Arctic is not the only source of POPs. Significant additional sources of food contamination occurs during its preparation, processing, storage, aging, and possibly cooking and might contribute significantly to the total exposure of aboriginal populations to POPs. This was revealed by comparing the concentrations of POPs in ready-to-eat local foods obtained from indigenous residences with those measured in tissues of freshly caught fish, reindeer meat and sea mammals tissues sampled (additional details are provided elsewhere (15–16)). Furthermore, nearly all of the indoor

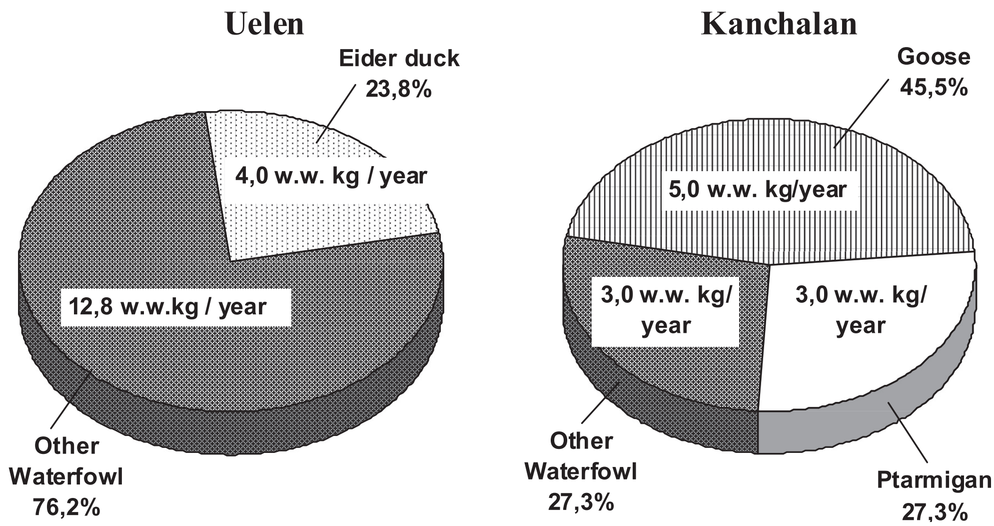
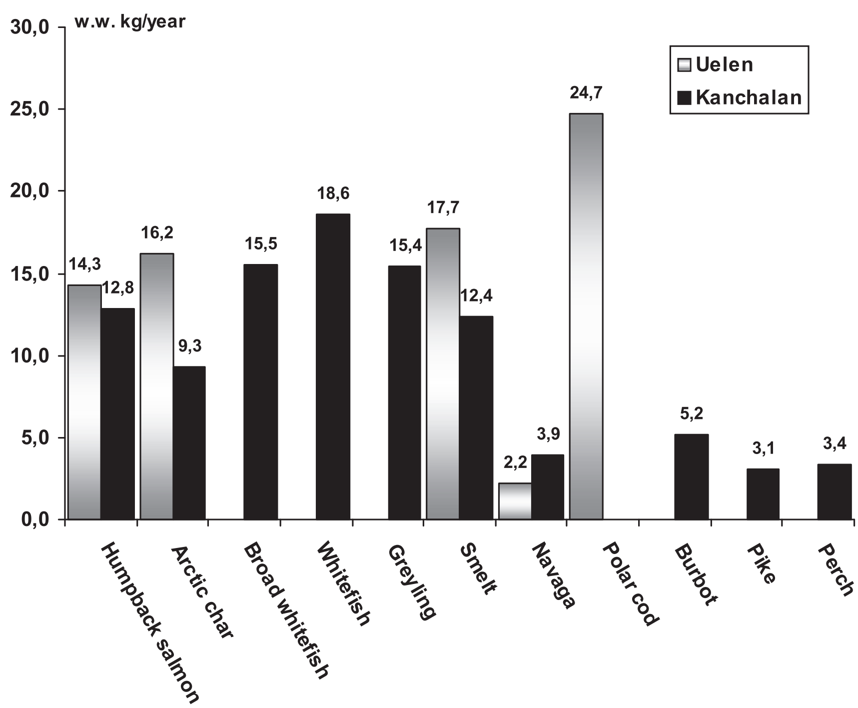


Fig. 5. Average annual consumption of birds (wet weight) by coastal Chukchi and Eskimo (Uelen) and inland Chukchi (Kanchalan); Chukotka, Russia (2001–2002).

environment samples analysed were polluted by DDTs, HCH, PCBs and other POPs. Home-made alcoholic drinks and fermented meat from ground pits were also highly polluted by PCBs and DDTs.

Another specific feature of the Russian northern settlements is the indoor abundance of cockroaches. Chronic use of pesticides against pests and insects has been carried out, which relied heavily of domestic



Humpback (pink) salmon (*Oncorhynchus gorbuscha*), Arctic char (*Salvelinus alpinus*), Broad whitefish (*Coregonus nasus*); Whitefish (*Coregonus lavaretus*); Greyling (*Thymallus arcticus*), Smelt (*Osmerus mordax*), Navaga (*Eleginus navaga*), Polar cod (*Boreagadus saida*), Burbot (*Lota lota*), Pike (*Esox lucius*), Perch (*Perca fluviatilis*).

Fig. 6. Average annual consumption (wet weight) of fish by coastal Chukchi and Eskimo (Uelen) and inland Chukchi (Kanchalan); Chukotka, Russia (2001–2002).

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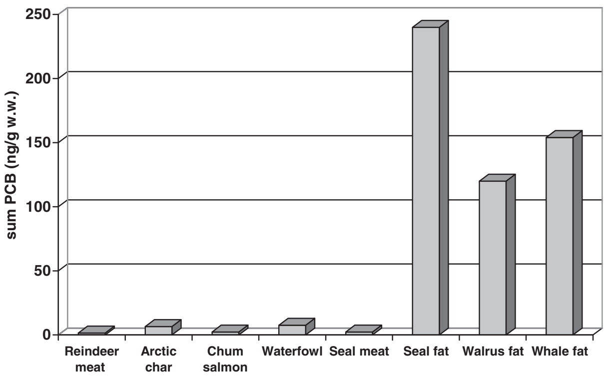

Fig. 7. The highest PCB concentrations (ng/g ww) in traditional food items in Chukotka (based on single samples).

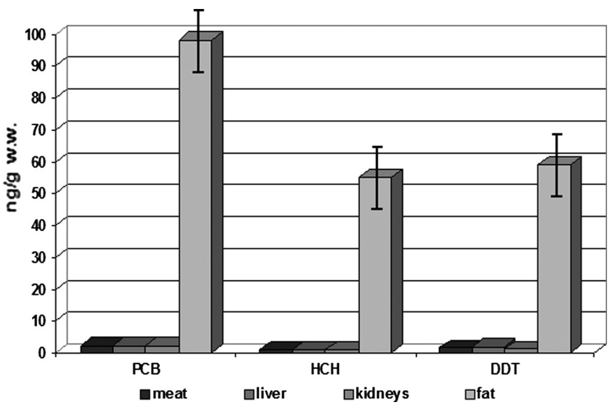

Fig. 8. Average levels of POPs in tissues of Ringed Seal, Chukotka (n = 14).

insecticides. Application of aerosols and powders containing insecticides to walls, tables, cabinets for food storage and surfaces for food preparation was practiced. As illustrated in Table IV, the pesticides used contained significant amounts of organochlorine compounds. They were mostly manufactured in China. Furthermore, but not unlike that documented for the Canadian north (4), abandoned military sites and radar stations are characterized by "industrial type" waste such as storage tanks and barrels used for storage of fuels and lubricants, rusting transport vehicles, electrical equipment (including transformers), as well as currently used dumpsites. Local soil contamination is thus highly likely.

The recommended safe intakes of traditional food items (see Table III) are supported by the relatively high concentrations of POPs and mercury found in the blood of the residents of Uelen and Kanchalan (3,7,17–20). Since cigarette smoke is the main source of cadmium, consumption of offal (specifically liver and kidneys) is primarily an issue for smokers. As pointed out in the footnote to Table II, the Russian MPDIs reflect current (for aldrin and heptachlor) or earlier (γ-HCH, HCB, DDT) WHO ATDIs or PTDIs. Similarly, the equivalent values used for total PCBs, mercury, lead and cadmium are currently still used as guidelines by Health Canada as pointed out earlier. Consequently, the recommended safe consumption rates reflect internationally used guidelines.

A number of measures were implemented to reduce the exposures to PTSs. Recommendations for systematic sanitary-epidemiological inspections were approved by

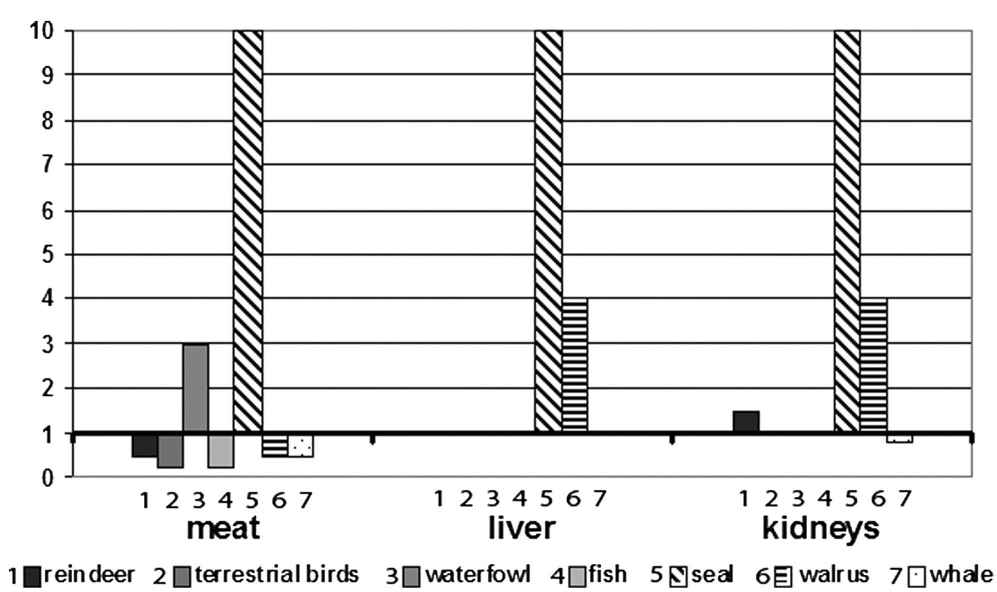

Fig. 9. Hg in tissues of animals expressed as fraction of the Russian Maximum Permissible Concentration (based on multiple samples). Details (type and number) of the animal tissues sampled are summarized in Chapters 5 and 6 of the 2004 AMAP report (7).

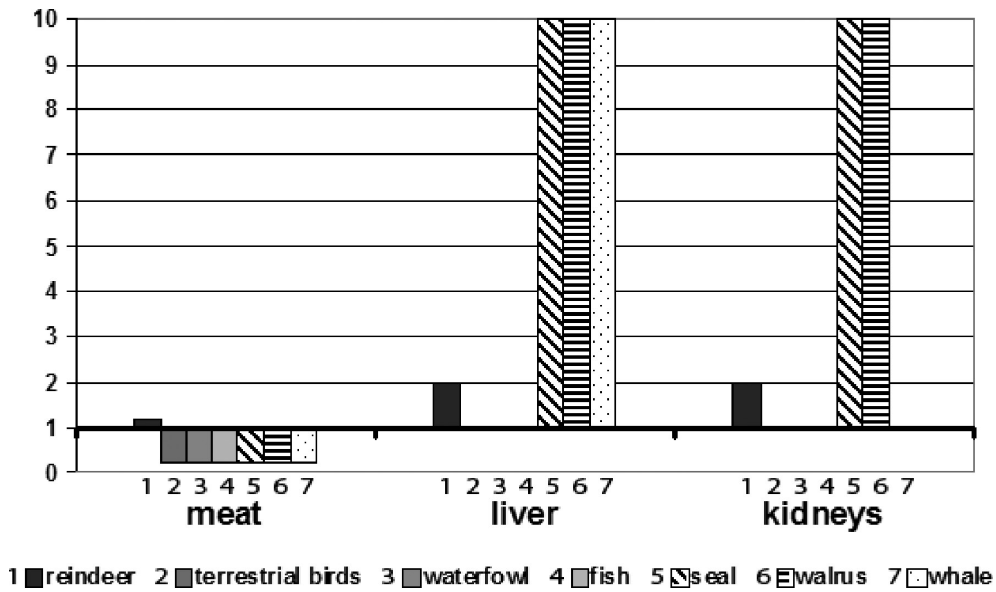

Fig. 10. Cd in tissues of animals expressed as a fraction of the Russian Maximum Permissible Concentrations (based on multiple samples). Details (type and number) of the animal tissues sampled are summarized in Chapters 5 and 6 of the 2004 AMAP report (7).

the Russian Federation Ministry of Health Care and Social Development of the Russian Federation (21). Two separate brochures were prepared for the inland and for coastal communities entitled: "What should be known about traditional nutrition in the Far North" (22,23). A film about PTSs in the Russian North was also prepared and distributed in the communities. Further, the results of the study have been reported at special sessions of representatives of the state authorities, local self-governments, health care organizations, educational institutions, non-governmental organizations, indigenous communities and the public, and served as a basis for decision making in Chukotka, Nenetsk and Taymir Autonomous Okrugs, and in Murmansk Oblast. A popular non-technical summary of the Russian Arctic PTSs project and its findings were presented in a special session of the Russian State Duma Committee in 2004. Media coverage of the issues was also prominent, including on local radio, television, and in newspapers in each region. A school educational program entitled "Basics of life activity in the Far North" was also prepared under the aegis of the Arctic Council Indigenous Peoples Secretariat (24).

Waste clean-up activities were started in coastal Chukotka in 2007. Two villages Lavrentiya and Lorino were the initial focus as they had serious problems

Table III. Recommended maximum daily (weekly, monthly) intakes of local animals for indigenous people of Russian Arctic based on POPs and metals food contamination

Local animal	Meat	Fat	Liver	Kidneys
Reindeer	Unrestricted		100 g/day	100 g/day
Hare	Unrestricted		Unrestricted	Unrestricted
Siberian moose	Unrestricted		Unrestricted	Unrestricted
Freshwater fish	400 g/day		100 g/day	
Anadromous fish	400 g/day		100 g/day	
Marine fish	Unrestricted		100 g/day	
Terrestrial birds	Unrestricted		100 g/day	
Waterfowl	400 g/week		100 g/day	
Whale	Unrestricted	400 g/day	100 g/month	Unrestricted
Walrus	Unrestricted	Unrestricted	100 g/month	100 g/month
Seal	100 g/week	100 g/week	100 g/month	100 g/month

Note: If the amount of a specific product is restricted it is recommended to avoid (or restrict to a minimum) simultaneous consumption of other restricted products. For children, pregnant (planning pregnancy and lactating) women the recommended maximum intakes listed should be lowered by a factor of 2.

Table IV. POPs concentrations in samples of household insecticides (retail), home-made alcohol, fresh and fermented (in ground pits) walrus meat, sampled in Chukotka in 2003 (single trials)

Stuff	Σ PCBs	HCB	Σ HCH	4,4′-DDE	4,4′-DDT	DDE/DDT
Agent against cockroach, (ng/g)	28	–	–	–	–	–
Agent against cockroach, (ng/g)	31	–	–	7.7	15	0.51
Agent against louse, (ng/g)	234	406	–	38	480	0.08
Agent against insects, (ng/g)	8.0	0.5	–	–	–	–
Agent against gadfly, (ng/g)	0.3	0.1	–	0.01	–	–
Cream against mosquitoes, (ng/g)	–	1.1	–	–	–	–
Homemade distilled strong alcohol, (ng/L)	82	3.3	33	39	44	0.9
Homemade fermented alcohol, (ng/L)	249	12.2	60	458	23	19.9
Fresh walrus meat, (ng/g ww)	2.9–3.2	0.1–0.3	0.1–0.2	0.1–0.3	0.1–0.2	1
Fermented walrus (in ground pit) meat (ng/g)	623	0.16	0.73	6.71	0.1	67.1

Note: Very high levels of PCBs, HCB and DDTs in the louse insecticide have no reasonable explanation. The high levels of PCBs and DDT in homemade fermented alcohol are likely connected to the contamination of containers used for its production and storage. In addition to the latter sources, contaminated soil may well contribute to the concentrations found in meats fermented in underground pits. The low values of the DDE/DDT ratio observed in some insecticides suggest the presence of "fresh" DDT and perhaps current use, while homemade fermented alcohol and fermented (in ground pit) walrus meat have "old" DDT origin.

with leaking and abandoned drums, which potentially were polluted with PCBs and other contaminants. Lectures and training sessions were organized locally for instructions on: how to identify the drums; sample their content; and sort, handle and store them appropriately. In the summer of 2008, a more general clean-up process was initiated.

Conclusions

In addition to characterizing the contaminant intake load of home-prepared traditional foods, a number of environmental outdoor and indoor exposure sources were identified (7). These include: poorly controlled use of toxic insecticides for the treatment of farmed animals; unrestricted household use of insecticides and other chemicals for combating insects and pests; liberal use of technical oils and liquids for treatment of wood and other construction materials; misuse of previously-used and contaminated industrial containers and barrels for pickling of plants and vegetables, the home-brewing of alcoholic drinks and for domestic water storage. The practice of prolonged fermentation of meat and fish in ground pits in coastal Chukotka may cause additional contamination of food due to poor sanitation, historic environmental abuse and prolonged neglect of the native communities and lands.

Clearly, local exposure factors are important and need investigation when comparing and interpreting measures of actual exposures, such as contaminant levels in body fluids between communities. The Russian PTS study (7) has demonstrated that such a dual sampling approach to assessing exposure can lead to improved public and political awareness and the implementation of exposure reduction measures.

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Nasivvik Centre for Inuit Health and Changing Environment has invited the author to submit this manuscript for publication in the IJCH, and to facilitate the writing and analysis process has provided the funding for the author.

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